Automation: Decision Aid or Decision Maker?

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Until recently, experienced human operators were the sole decision-makers involved in the operation of commercial aircraft. However, ever increasing and sophisticated technological advances have introduced new forms of "decision makers" into the cockpit environment. The advent of the glass cockpit and flight management and warning systems have changed the decision making environment of the commercial aircraft cockpit in both subtle and overt ways. Flight management systems are taking on increasing control of flight operating systems as more and more tasks, such as calculating and flying more fuel efficient paths, detection of malfunctions and abnormalities, are delegated to them. We began work on a series of studies during the last year to begin examination of the psychological and decision making consequences of increasing automated control in the cockpit.

Automation Bias

Of particular interest has been increasing documentation of possible "automation bias". Automation bias occurs when people fail to notice problems because an automated aid fails to detect them (an **omission error**) or when people inappropriately follow an automated decision aid directive (a **commission error**). Automated decision aids, by virtue of their simple heuristic value, act as very salient decisional cues, and diminish the likelihood that decision makers will process information in cognitively complex ways. Automated aids are by design very "bright lights" and ones that may engulf or overwhelm other diagnostic information. Moreover, humans may be disinclined to make the cognitive effect to seek out other diagnostic information to the extent that automated feedback is believed to be generally reliable. They may become focused on the information provided by the decision aid, cutting off situation assessment prematurely, or, to the extent that they notice additional information, they may show assimilation, discounting or confirmatory biases. Information from non-automated sources may be interpreted as being more consistent with automated feedback than it actually is (assimilation) or cues completely inconsistent with automated feedback may be discounted as relatively unimportant. Confirmatory biases lead information processors to over-attend to consistent information, and to ignore other data (e.g., Lord, Ross & Lepper, 1979). In combination, normal information processing heuristics and often attending cognitive biases may prime people to over-attend to automated directives, and in turn, to under-attend to other sources of information that might disconfirm the automation.

Because it is cognitively easier to delegate tasks to automation, people are therefore likely to do so when automated aids are available. Because automated aids, when used correctly, are generally accurate, this heuristic will generally be effective. Airplanes fly safely, medical diagnoses are made correctly, power plants function efficiently. However indiscriminate or inappropriate reliance on automation will result in errors, jut as inappropriate use of other decision-making heuristics results in errors. Delegating to automation has the additional consequence of making human decision makers less attentive, and unlikely to notice aberrant events that are not brought to their explicit attention by the system. Similarly, when automated decision aids indicate problems or make recommendations, the path of least resistance is to accept these judgments at face value.

Our research during the first year of this funding period has explored these issues in a variety of ways, with the primary goal of establishing that automation bias in fact is an issue of concern in cockpit decision making, narrowing down the class of possible variables that might predict when automation bias is likely to occur, and to begin to understand the possible underlying decisional dynamics of automation bias in order to better understand how to ameliorate it. These goals were met by conducting three major studies: (1) An archival analysis of Aviation Safety Reporting System (ASRS) data for reports of events involving automation, (2) A laboratory study conducted at Southern Illinois University at Edwardsville (SIUE) using hypothetical decision making scenarios to examine the breadth of automation bias, as well as testing competing hypotheses for why automation bias occurs (e.g., diffusion of responsibility versus an authority hypothesis, and (3) A study run both at NASA-Ames and SIUE using a computerized part-task and student samples to examine the prevalence of omission and

commission errors in a decision making situation that more closely approximates the flight cockpit environment.

Examination of ASRS Data

One-hundred sixty-six reports involving automated control systems (e.g., autopilot and FMS) in conjunction with some kind of error were retrieved from ASRS. The purpose of this analysis was to verify that over reliance on automation occurs in real airspace, with negative or potentially negative consequences, and to examine possible situational and contextual trends in the data (i.e., whether occurrences happened during particular flight phases, or involve particular clearances or flight functions). Due to the nature of ASRS data, the sample is, of course, neither random nor completely representative of all possible incidences (e.g., most of the incidents in the data set involved ATC intervention; however crews would be more likely to report an error it ATC was involved to take advantage of the non-enforcement benefits of submitting a report). The sample does, however, establish the existence of a particular incident, and represents a minimum baserate for a possible automation bias. Reports were coded with respect to the anomaly, the system involved, who reported it, who first detected it and intervened, its resolution, flight stage, and automation and crew factors involved. Roughly half the reports involved the FMS; the rest referred to only "autopilot," although a more sophisticated system may have been involved.

This analysis revealed indications that automation does have the impact of creating omission and commission errors in real flight decision making contexts. For over half of the instances, the automated system was correct -- that is, it was functioning exactly as it was designed. In 75% of these cases, the crew admitted to an error in setting or programming the system. Many of the cases in which the system did not perform as programmed involved altitude deviations (e.g., failure to capture altitude on climb or descent). Crews cited complacency or lack of vigilance in monitoring whether the automation was performing as expected in 77% of the reports, suggesting that errors of omission is the most common form of automation bias (that is, not noticing when the automation is not performing as expected, or an over-delegation of responsibility to the automated system). Fatigue was reported in 9% of the incidents, and in 7% some kind of conceptual or cognitive misunderstanding of the system was involved.

In further support of higher risk of omission errors as a function of automation than commission errors was the results as a function of flight phase. Pilots were at greatest risk for missing events or discrepancies during the cruise flight phase. In 81% of the cruise events, the crews cited either complacency or non-vigilance as a factor. In 51% of these events, the system was performing as it was programmed to do, but the crew missed that they had mis-programmed the system.

The Scenario Study

The scenario study examined the decisions of 357 college students to hypothetical decision making vignettes to examine the extent to which automation bias applies cross-situationally, and how automated directives or influence might differ from the influence of a human agent. Specifically, we examined whether people tend to over-attend to the influence of automation bias in highly technological domains or whether it is more pervasive-- that people endow computers/automation with some form of expertise or authority that applies regardless of situation and more powerfully than human influence agents. In addition, it explored the effects of automated directives in the absence of such distractions as buzzers, flashing lights, and put it in simple and more controlled competition with other sources of information. Subjects read a decision making scenario in one of six decision making domains: the flight cockpit, a nuclear power plant, dating service, and two stock market scenarios (a loss and a gain situation), and an automobile. In each of the decision making scenarios, sufficient information was provided to indicate a reasonable decision outcome. All scenarios also described advice from an external source making suggestions to make a decision that was completely at odds with all of the objective data provided in the scenario-- to follow the advice of the external agent would be making a commission error. Half the decision making scenarios included recommendations for a decision outcome by a person; the other half were advised by a computerized decision aid.

Publications and Presentations:

Skitka, L. J. & Mosier, K. L. (1994). Automation bias: When, where and why? Paper presented at the Judgment and Decision Making Society annual convention, St. Louis, MO.

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Mosier, K. L. & Skitka, L. J. (under review) Human decision makers and automated decision aids: Made for each other?

Mosier, K. L. & Skitka, L. J. (under review) Errors of omission and commission: Issues of the automated cockpit.

Heers, S. T., Marchioro, C. A., Mosier, K. L., & Skitka, L. J. (1994). Automation and accountability in a low fidelity flight task. Paper presented at the annual Human Factors and Ergonomics Society meeting, Nashville, TN.